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Scalar partner of Z^0-boson with larger mass value than Z^0-boson mass in Subquark model

Takeo Matsushima *

1-17-1 Azura Ichinomiya,†
Aichi-Prefecture, Japan

Abstract

The subquark model previously proposed by us showes that the intermediate Z^0-boson is realized as the composite object and its scalar partner has the mass value larger than Z^0-boson mass, which is about 110 GeV.

* † e-mail : mtakeo@eken.phys.nagoya-u.ac.jp

1 Introduction

The discovery of the top-quark[1] has finally confirmed the existence of three quark-lepton symmetric generations. So far the standard $SU(2)_L \otimes U(1)$ model (denoted by SM) has successfully explained various experimental evidences. Nevertheless, as is well known, the SM is not regarded as the final theory because it has many arbitrary parameters, e.g., quark and lepton masses, quark-mixing parameters and the Weinberg angle, etc. . Therefore it is meaningful to investigate the origins of these parameters and the relationship among them. In order to overcome such problems some attempts have done, e.g., Grand Unification Theory (GUT); Supersymmetry(SUSY); SUGY-GUT; Composite model; etc. . In the GUT scenario quarks and leptons are elementary fields in general. On the contrary in the composite scenario they are literally the composite objects constructed from the elementary fields (so called "preon"). The lists of various related works are in ref.[2]. If quarks and leptons are elementary, in order to solve the above problems it is necessary to introduce some external relationship or symmetries among them. On the other hand the composite models have ability to explain the origin of these parameters in terms of the substructure dynamics of quarks and leptons. Further, the composite scenario naturally leads us to the thought that the intermediate vector bosons of weak interactions ($\mathbf{W}, \mathbf{Z}$) are not elementary gauge fields (which is so in the SM) but composite objects constructed from preons (same as ρ -meson from quarks). Many studies based on such conception have done after Bjorken's[3] and Hung and Sakurai's[4] suggestions of the alternative way to unified weak-electromagnetic gauge theory[5-11]. In this scheme the weak interactions are regarded as the effective residual interactions among preons. The fundamental fields for intermediate forces are massless gauge fields belonging to some gauge groups and they confine preons into singlet states to build quarks and leptons and $\mathbf{W}, \mathbf{Z}$.

The conception of our model is that the fundamental interacting forces are all originated from massless gauge fields belonging to the adjoint representations of some gauge groups which have nothing to do with the spontaneous breakdown and that the elementary matter fields are only one kind of spin-1/2 preon and spin-0 preon carrying common "$e/6$" electric charge ($e > 0$). Quarks, leptons and $\mathbf{W}, \mathbf{Z}$ are all composites of them and usual weak interactions are regarded as effective residual interactions. Based on such idea we consider the underlying gauge theory in section 2 and composite model in section 3. In section 4 we discuss about the mass(denoted by $M(S^0)$) of the scalar partner(denoted by S^0) of Z^0-boson.

2 Gauge theory inspiring quark-lepton composite scenario

In our model the existence of fundamental matter fields (preon) are inspired by the gauge theory with Cartan connections[14]. Let us briefly summarize the basic features of that. Generally gauge fields, including gravity, are considered as geometrical objects, that is, connection coefficients of principal fiber bundles. It is said that there exist some different points between Yang-Mills gauge theories and gravity, though both theories commonly possess fiber bundle structures. The latter has the fiber bundle related essentially to 4-dimensional space-time freedoms but the former is given, in an ad hoc way, the one with the internal space which has nothing to do with the space-time coordinates. In case of gravity it is usually considered that there exist ten gauge fields, that is, six spin connection fields in $SO(1,3)$ gauge group and four vierbein fields in $GL(4,R)$ gauge group from which the metric tensor $\mathbf{g}^{\mu\nu}$ is constructed in a bilinear function of them. Both altogether belong to Poincaré group $ISO(1,3) = SO(1,3) \otimes R^4$ which is semi-direct product. In this scheme spin connection fields and vierbein fields are independent but only if there is no torsion, both come to have some relationship. Seeing this, $ISO(1,3)$ gauge group theory has the logical weak point not to answer how two kinds of gravity fields are related to each other intrinsically.

In the theory of Differential Geometry, S.Kobayashi has investigated the theory of "Cartan connection"[15]. This theory, in fact, has ability to reinforce the above weak point. The brief recapitulation is as follows. Let $E(B_n, F, G, P)$ be a fiber bundle (which we call Cartan-type bundle) associated with a principal fiber bundle $P(B_n, G)$ where B_n is a base manifold with dimension "n", G is a structure group, F is a fiber space which is homogeneous and diffeomorphic with G/G' where G' is a subgroup of G. Let $P' = P'(B_n, G')$ be a principal fiber bundle, then P' is a subbundle of P. Here let it be possible to decompose the Lie algebra $\mathbf{g}$ of G into the subalgebra $\mathbf{g}'$ of G' and a vector space $\mathbf{f}$ such as :

$$\mathbf{g} = \mathbf{g}' + \mathbf{f}, \qquad \mathbf{g}' \cap \mathbf{f} = 0, \tag{1}$$

$$[\mathbf{g}', \mathbf{g}'] \subset \mathbf{g}', \tag{2}$$

$$[\mathbf{g}', \mathbf{f}] \subset \mathbf{f}, \tag{3}$$

$$[\mathbf{f}, \mathbf{f}] \subset \mathbf{g}', \tag{4}$$

where $dim\mathbf{f} = dimF = dimG - dimG' = dimB_n = n$. The homogeneous space $F = G/G'$ is said to be "weakly reductive" if there exists a vector space $\mathbf{f}$ satisfying Eq.(1) and (3). Further F satisfying Eq(4) is called "symmetric space". Let ω denote the connection form of P and $\overline{\omega}$ be the restriction of ω to P'. Then $\overline{\omega}$ is a $\mathbf{g}$-valued linear differential 1-form and we have :

$$\omega = g^{-1}\overline{\omega}g + g^{-1}dg, \tag{5}$$

where $g \in G$, $dg \in T_g(G)$. ω is called the form of "Cartan connection" in P.

Let the homogeneous space $F = G/G'$ be weakly reductive. The tangent space $T_O(F)$ at $o \in F$ is isomorphic with $\mathbf{f}$ and then $T_O(F)$ can be identified with $\mathbf{f}$ and also there exists a linear $\mathbf{f}$-valued differential 1-form(denoted by θ) which we call the "form of soldering". Let ω' denote a $\mathbf{g}'$-valued 1-form in P', we have :

$$\overline{\omega} = \omega' + \theta. \tag{6}$$

The dimension of vector space $\mathbf{f}$ and the dimension of base manifold B_n is the same "n", and then $\mathbf{f}$ can be identified with the tangent space of B_n at the same point in B_n and θs work as n-bein fields. In this case ω' and θ unifyingly belong to group G. Here let us call such a mechanism "Soldering Mechanism".

Drechsler has found out the useful aspects of this theory and investigated a gravitational gauge theory based on the concept of the Cartan-type bundle equipped with the Soldering Mechanism[16]. He considered $F = SO(1,4)/SO(1,3)$ model. Homogeneous space F with $dim = 4$ solders 4-dimensional real space-time. The Lie algebra of $SO(1,4)$ corresponds to $\mathbf{g}$ in Eq.(1), that of $SO(1,3)$ corresponds to $\mathbf{g}'$ and $\mathbf{f}$ is 4-dimensional vector space. The 6-dimensional spin connection fields are $\mathbf{g}'$-valued objects and vierbein fields are $\mathbf{f}$-valued, both of which are unified into the members of $SO(1,4)$ gauge group. We can make the metric tensor $\mathbf{g}^{\mu\nu}$ as a bilinear function of $\mathbf{f}$-valued vierbein fields. Inheriting Drechsler's study the author has investigated the quantum theory of gravity[14]. The key point for this purpose is that F is a symmetric space because $\mathbf{f}$s are satisfied with Eq.(4). Using this symmetric nature we can pursue making a quantum gauge theory, that is, constructing $\mathbf{g}'$-valued Faddeev-Popov ghost, anti-ghost, gauge fixing, gaugeon and its pair field as composite fusion fields of $\mathbf{f}$-valued gauge fields by use of Eq.(4) and also naturally inducing BRS-invariance.

Comparing such a scheme of gravity, let us consider Yang-Mills gauge theories. Usually when we make the Lagrangian density $\mathcal{L} = tr(\mathcal{F} \wedge \mathcal{F}^*)$ ($\mathcal{F}$ is a field strength), we must borrow a metric tensor $\mathbf{g}^{\mu\nu}$ from gravity to get $\mathcal{F}^*$ and also for Yang-Mills gauge fields to propagate in the 4-dimensional real space-time. This seems to mean that "there is a hierarchy between gravity and other three gauge fields (electromagnetic, strong, and weak)". But is it really the case ? As an alternative thought we can think that all kinds of gauge fields are "equal". Then it would be natural for the question "What kind of equality is that ?" to arise. In other words, it is the question that "What is the minimum structure of the gauge mechanism which four kinds of forces are commonly equipped with ?". For answering this question, let us make a assumption : "*Gauge fields are Cartan connections equipped with Soldering Mechanism*." In this meaning all gauge fields are equal. If it is the case three gauge fields except gravity are also able to have their own metric tensors and to propagate in the real space-time without the help of gravity. Such a model has already investigated in ref.[14].

Let us discuss them briefly. It is found that there are four types of sets of classical groups with small dimensions which admit Eq.(1,2,3,4), that is, $F = SO(1,4)/SO(1,3)$, $SU(3)/U(2)$, $SL(2,C)/GL(1,C)$ and $SO(5)/SO(4)$ with $dimF = 4$[17]. Note that the quality of "dim 4" is very important because it guarantees F to solder to 4-dimensional real space-time and all gauge fields to work in it. The model of $F = SO(1,4)/SO(1,3)$ for gravity is already mentioned. Concerning other gauge fields, it seems to be appropriate to assign $F = SU(3)/U(2)$ to QCD gauge fields, $F = SL(2,C)/GL(1,C)$ to QED gauge fields and $F = SO(5)/SO(4)$ to weak interacting gauge fields. Some discussions concerned are following. In general, matter fields couple to $\mathbf{g}'$-valued gauge fields. As for QCD, matter fields couple to the gauge fields of $U(2)$ subgroup but $SU(3)$ contains, as is well known, three types of $SU(2)$ subgroups and then after all they couple to all members of $SU(3)$ gauge fields. In case of QED, $GL(1,C)$ is locally isomorphic with $C^1 \cong U(1) \otimes R$. Then usual Abelian gauge fields are assigned to $U(1)$ subgroup of $GL(1,C)$. Georgi and Glashow suggested that the reason why the electric charge is quantized comes from the fact that $U(1)$ electromagnetic gauge group is a unfactorized subgroup of $SU(5)$[18]. Our model is in the same situation because $GL(1,C)$ a unfactorized subgroup of $SL(2,C)$. For usual electromagnetic $U(1)$ gauge group, the electric charge unit "e"($e > 0$) is for *one generator* of $U(1)$ but in case of $SL(2,C)$ which has *six generators*, the minimal unit of electric charge shared per one generator must be "$e/6$". This suggests that quarks and leptons might have the substructure simply because $e,\ 2e/3,\ e/3 > e/6$. Finally as for weak interactions we adopt $F = SO(5)/SO(4)$.

It is well known that $SO(4)$ is locally isomorphic with $SU(2) \otimes SU(2)$. Therefore it is reasonable to think it the left-right symmetric gauge group : $SU(2)_L \otimes SU(2)_R$. As two $SU(2)$s are direct product, it is able to have coupling constants $(\mathbf{g}_L, \mathbf{g}_R)$ independently. This is convenient to explain the fact of the disappearance of right-handed weak interactions in the low-energy region. Possibility of composite structure of quarks and leptons suggested by above $SL(2, C)$-QED would introduce the thought that the usual left-handed weak interactions are intermediated by massive composite vector bosons as ρ-meson in QCD and that they are residual interactions due to substructure dynamics of quarks and leptons. The elementary massless gauge fields ,“ *as connection fields"*, relate intrnsically to the structure of the real space-time manifold but on the other hand the composite vector bosons have nothing to do with it. Considering these discussions, we set the assumption : “*All kinds of gauge fields are elementary massless fields, belonging to spontaneously unbroken* $SU(3)_C \otimes SU(2)_L \otimes SU(2)_R \otimes U(1)_{e.m}$ *gauge group and quarks and leptons and* **W, Z** *are all composite objects of the elementary matter fields.*”

3 Composite model

Our direct motivation towards compositeness of quarks and leptons is one of the results of the arguments in Sect.2, that is, e, $2e/3$, $e/3 > e/6$. However, other several phenomenological facts tempt us to consider a composite model, e.g., repetition of generations, quark-lepton parallelism of weak isospin doublet structure, quark-flavor-mixings, etc.. Especially Bjorken[3]'s and Hung and Sakurai[4]'s suggestion of an alternative to unified weak-electromagnetic gauge theories have invoked many studies of composite models including composite weak bosons[5-11]. Our model is in the line of those studies. There are two ways to make composite models, that is, “Preons are all fermions.” or “Preons are both fermions and bosons (denoted by FB-model).” The merit of the former is that it can avoid the problem of a quadratically divergent self-mass of elementary scalar fields. However, even in the latter case such a disease is overcome if both fermions and bosons are the supersymmetric pairs, both of which carry the same quantum numbers except the nature of Lorentz transformation (spin-1/2 or spin-0)[19]. Pati and Salam have suggested that the construction of a neutral composite object (neutrino in practice) needs both kinds of preons, fermionic as well as bosonic, if they carry the same charge for the Abelian gauge or belong to the same (fundamental) representation for the non-Abelian gauge[20]. This is a very attractive idea

for constructing the minimal model. Further, according to the representation theory of Poincaré group both integer and half-integer spin angular momentum occur equally for massless particles[21], and then if nature chooses "fermionic monism", there must exist the additional special reason to select it. Therefore in this point also, the thought of the FB-model is minimal. Based on such considerations we propose a FB-model of *"only one kind of spin-1/2 elementary field (denoted by Λ) and of spin-0 elementary field (denoted by Θ)"* (preliminary version of this model has appeared in Ref.[14]). Both have the same electric charge of "$e/6$" (Maki has first proposed the FB-model with the minimal electric charge $e/6$. [22]) [1] and the same transformation properties of the fundamental representation (3, 2, 2) under the spontaneously unbroken gauge symmetry of $SU(3)_C \otimes SU(2)_L \otimes SU(2)_R$ (let us call $SU(2)_L \otimes SU(2)_R$ "hypercolor gauge symmetry"). Then Λ and Θ come into the supersymmetric pair which guarantees 'tHooft's naturalness condition[23]. The $SU(3)_C$, $SU(2)_L$ and $SU(2)_R$ gauge fields cause the confining forces with confining energy scales of $\Lambda_c << \Lambda_L < (or \cong)\Lambda_R$ (Schrempp and Schrempp discussed this issue elaborately in Ref.[11]). Here we call positive-charged primons (Λ, Θ) "*matter*" and negative-charged primons ($\overline{\Lambda}$, $\overline{\Theta}$) "*antimatter*". Our final goal is to build quarks, leptons and $\mathbf{W}, \mathbf{Z}$ from Λ ($\overline{\Lambda}$) and Θ ($\overline{\Theta}$). Let us discuss that scenario next.

At the very early stage of the development of the universe, the matter fields (Λ, Θ) and their antimatter fields ($\overline{\Lambda}$, $\overline{\Theta}$) must have broken out from the vaccum. After that they would have combined with each other as the universe was expanding. That would be the first step of the existence of composite matters. There are ten types of them :

$spin\frac{1}{2}$	$spin\ 0$	$e.m.charge$	$Y.M.representation$	
$\Lambda\Theta$	$\Lambda\Lambda, \Theta\Theta$	$\frac{1}{3}e$	$(\overline{3}, 1, 1)\ \ (\overline{3}, 3, 1)\ \ (\overline{3}, 1, 3),$	(7a)
$\Lambda\overline{\Theta}, \overline{\Lambda}\Theta$	$\Lambda\overline{\Lambda}, \Theta\overline{\Theta}$	0	$(1, 1, 1)\ \ (1, 3, 1)\ \ (1, 1, 3),$	(7b)
$\overline{\Lambda\Theta}$	$\overline{\Lambda\Lambda}, \overline{\Theta\Theta}$	$-\frac{1}{3}e$	$(3, 1, 1)\ \ (3, 3, 1)\ \ (3, 1, 3).$	(7c)

In this step the confining forces are, in kind, in $SU(3) \otimes SU(2)_L \otimes SU(2)_R$ gauge symmetry but the $SU(2)_L \otimes SU(2)_R$ confining forces must be main because of the energy scale of $\Lambda_L, \Lambda_R >> \Lambda_c$ and then the color gauge coupling α_s and e.m. coupling constant α are negligible. As is well known, the coupling constant of $SU(2)$ confining force are characterized by $\varepsilon_i = \sum_a \sigma_p^a \sigma_q^a$,where σs are 2×2 matrices of $SU(2)$, $a = 1, 2, 3$, $p, q =$

[1]The notations of Λ and Θ are inherited from those in Ref.[22]. After this we call Λ and Θ "Primon" named by Maki which means "primordial particle"[22].

$\Lambda, \overline{\Lambda}, \Theta, \overline{\Theta}$, $i = 0$ for singlet and $i = 3$ for triplet. They are calculated as $\varepsilon_0 = -3/4$ which causes the attractive force and and $\varepsilon_3 = 1/4$ causing the repulsive force. Next, $SU(3)_C$ octet and sextet states are repulsive but singlet, triplet and antitriplet states are attractive and then the formers are disregarded. Like this, two primons are confined into composite objects in more than one singlet state of any $SU(3)_C, SU(2)_L, SU(2)_R$. Note that three primon systems cannot make the singlet states of $SU(2)$. Then we omit them. In Eq.(7b), the $(1,1,1)$-state is the "most attractive channel". Therefore $(\Lambda\overline{\Theta})$, $(\overline{\Lambda}\Theta)$, $(\Lambda\overline{\Lambda})$ and $(\Theta\overline{\Theta})$ of $(1,1,1)$-states with neutral e.m. charge must have been most abundant in the universe. Further $(\overline{3},1,1)$- and $(3,1,1)$-states in Eq.(7a,c) are next attractive. They presumably go into $\{(\Lambda\Theta)(\overline{\Lambda\Theta})\}, \{(\Lambda\Lambda)(\overline{\Lambda\Lambda})\}$, etc. of $(1,1,1)$-states with neutral e.m. charge. These objects may be the candidates for the "cold dark matters" if they have even tiny masses. It is presumable that the ratio of the quantities between the ordinary matters and the dark matters firstly depends on the color and hypercolor charges and the quantity of the latter much exesses that of the former (maybe the ratio is more than $1/(3\times3)$). Finally the $(*,3,1)$-and $(*,1,3)$-states are remained ($*$ is $1,3,\overline{3}$). They are also stable because $|\varepsilon_0| > |\varepsilon_3|$. They are, so to say, the "intermediate clusters" towards constructing ordinary matters(quarks,leptons and $\mathbf{W},\mathbf{Z}$). [2] Here we call such intermediate clusters "subquarks" and denote them as follows :

			Y.M.representation		spin	e.m.charge	
α	$=$	$(\Lambda\Theta)$	$\alpha_L : (\overline{3},3,1)$	$\alpha_R : (\overline{3},1,3)$	$\frac{1}{2}$	$\frac{1}{3}e$	(8a)
β	$=$	$(\Lambda\overline{\Theta})$	$\beta_L : (1,3,1)$	$\beta_R : (1,1,3)$	$\frac{1}{2}$	0	(8b)
$\mathbf{x}$	$=$	$(\Lambda\Lambda,\ \Theta\Theta)$	$\mathbf{x}_L : (\overline{3},3,1)$	$\mathbf{x}_R : (\overline{3},1,3)$	0	$\frac{1}{3}e$	(8c)
$\mathbf{y}$	$=$	$(\Lambda\overline{\Lambda}\ \Theta\overline{\Theta})$	$\mathbf{y}_L : (1,3,1)$	$\mathbf{y}_R : (1,1,3)$	0	$0,$	(8d)

and there are also their antisubquarks[9]. [3]

Now we come to the step to build quarks and leptons. The gauge symmetry of the confining forces in this step is also $SU(2)_L \otimes SU(2)_R$ because the subquarks are in the triplet states of $SU(2)_{L,R}$ and then they are combined into singlet states by the decomposition of $3 \times 3 = 1 + 3 + 5$ in $SU(2)$. We make the first generation of quarks

[2] Such thoughts have been proposed by Maki in Ref.[22]

[3] The notations of α,β, $\mathbf{x}$ and $\mathbf{y}$ are inherited from those in Ref.[9] written by Fritzsch and Mandelbaum, because ours is, in the subquark level, similar to theirs with two fermions and two bosons. R. Barbieri, R. Mohapatra and A. Masiero proposed the similar model[9].

and leptons as follows :

$$\begin{array}{rclccr}
 & & & e.m.charge & Y.M.representation & \\
<\mathbf{u}_h| & = & <\alpha_h\mathbf{x}_h| & \frac{2}{3}e & (3,1,1) & (9a)\\
<\mathbf{d}_h| & = & <\overline{\alpha}_h\overline{\mathbf{x}}_h\mathbf{x}_h| & -\frac{1}{3}e & (3,1,1) & (9b)\\
<\nu_h| & = & <\alpha_h\overline{\mathbf{x}}_h| & 0 & (1,1,1) & (9c)\\
<\mathbf{e}_h| & = & <\overline{\alpha}_h\overline{\mathbf{x}}_h\overline{\mathbf{x}}_h| & -e & (1,1,1), & (9d)
\end{array}$$

where h stands for L(left handed) or R(right handed)[5]. [4]. Here we note that β and $\mathbf{y}$ do not appear. In practice $((\beta\mathbf{y}) : (1,1,1))$-particle is a candidate for neutrino. But as Bjorken has pointed out[3], non-vanishing charge radius of neutrino is necessary for obtaining the correct low-energy effective weak interaction Lagrangian. Therefore β is assumed not to contribute to forming ordinary quarks and leptons. However $(\beta\mathbf{y})$-particle may be a candidate for "sterile neutrino". Presumably composite $(\beta\beta)$-; $(\beta\overline{\beta})$-;$(\overline{\beta\beta})$-states may go into the dark matters. It is also noticeable that in this model the leptons have finite color charge radius and then $SU(3)$ gluons interact directly with the leptons at energies of the order of, or larger than Λ_L or Λ_R[19].

Concerning the confinements of primons and subquarks, the confining forces of two steps are in the same spontaneously unbroken $SU(2)_L \otimes SU(2)_R$ gauge symmetry. It is known that the running coupling constant of the $SU(2)$ gauge theory satisfies the following equation :

$$\frac{1}{\alpha_W^a(Q_1^2)} = \frac{1}{\alpha_W^a(Q_2^2)} + b_2(a)\ln\left(\frac{Q_1^2}{Q_2^2}\right), \tag{10a}$$

$$b_2(a) = \frac{1}{4\pi}\left(\frac{22}{3} - \frac{2}{3}\cdot N_f - \frac{1}{12}\cdot N_s\right), \tag{10b}$$

where N_f and N_s are the numbers of fermions and scalars contributing to the vacuum polarizations, $(a = q)$ for the confinement of subquarks in quark and $(a = sq)$ for confinement of primons in subquark. We calculate $b_2(q) = 0.35$ which comes from that the number of confined fermionic subquarks are 4 ($\alpha_i, i = 1,2,3$ for color freedom, β) and 4 for bosons $(\mathbf{x}_i, \mathbf{y})$ contributing to the vacuum polarization, and $b_2(sq) = 0.41$ which is calculated with three kinds of Λ and Θ owing to three color freedoms. Experimentary it is reported that $\Lambda_q > 1.8$ TeV(CDF exp.)[13] or $\Lambda_q > 2.4$ TeV(D0

[4]Subquark configurations in Eq.(9) are essentially the same as those in Ref.[5] written by Królikowski, who proposed the model of one fermion and one boson with the same e.m. charge $e/3$

exp.)[12]. Extrapolations of α_W^q and α_W^{sq} to near Plank scale are expected to converge to the same point and then tentatively, setting $\Lambda_q = 5$ TeV, $\alpha_W^q(\Lambda_q) = \alpha_W^{sq}(\Lambda_{sq}) = \infty$, we get $\Lambda_{sq} = 10^3\Lambda_q$,

Next let us see the higher generations. Harari and Seiberg have stated that the orbital and radial excitations seem to have the wrong energy scale (order of $\Lambda_{L,R}$) and then the most likely type of excitations is the addition of preon-antipreon pairs[6,25]. In our model the essence of generation is like "*isotope*" in case of nucleus. Then using $\mathbf{y}_{L,R}$ in Eq.(8,d) we construct them as follows :

$$\left\{\begin{array}{lcl} <\mathbf{c}| &=& <\alpha\mathbf{x}\mathbf{y}| \\ <\mathbf{s}| &=& <\overline{\alpha}\overline{\mathbf{x}}\mathbf{x}\mathbf{y}|, \end{array}\right. \quad \left\{\begin{array}{lcl} <\nu_\mu| &=& <\alpha\overline{\mathbf{x}}\mathbf{y}| \\ <\mu\ | &=& <\overline{\alpha}\overline{\mathbf{x}}\overline{\mathbf{x}}\mathbf{y}|, \end{array}\right. \qquad \text{2nd generation} \tag{11a}$$

$$\left\{\begin{array}{lcl} <\mathbf{t}| &=& <\alpha\mathbf{x}\mathbf{y}\mathbf{y}| \\ <\mathbf{b}| &=& <\overline{\alpha}\overline{\mathbf{x}}\mathbf{x}\mathbf{y}\mathbf{y}|, \end{array}\right. \quad \left\{\begin{array}{lcl} <\nu_\tau| &=& <\alpha\overline{\mathbf{x}}\mathbf{y}\mathbf{y}| \\ <\tau\ | &=& <\overline{\alpha}\overline{\mathbf{x}}\overline{\mathbf{x}}\mathbf{y}\mathbf{y}|, \end{array}\right. \qquad \text{3rd generation,} \tag{11b}$$

where the suffix L, Rs are omitted for brevity. We can also make vector and scalar particles with (1,1,1) :

$$\left\{\begin{array}{lcl} <\mathbf{W}^+| &=& <\alpha^\uparrow\alpha^\uparrow\mathbf{x}| \\ <\mathbf{W}^-| &=& <\overline{\alpha}^\uparrow\overline{\alpha}^\uparrow\overline{\mathbf{x}}|, \end{array}\right. \quad \left\{\begin{array}{lcl} <\mathbf{Z}_1^0| &=& <\alpha^\uparrow\overline{\alpha}^\uparrow| \\ <\mathbf{Z}_2^0| &=& <\alpha^\uparrow\overline{\alpha}^\uparrow\mathbf{x}\overline{\mathbf{x}}|, \end{array}\right. \qquad \text{Vector} \tag{12a}$$

$$\left\{\begin{array}{lcl} <\ \mathbf{S}^+| &=& <\alpha^\uparrow\alpha^\downarrow\mathbf{x}| \\ <\ \mathbf{S}^-| &=& <\overline{\alpha}^\uparrow\overline{\alpha}^\downarrow\mathbf{x}|, \end{array}\right. \quad \left\{\begin{array}{lcl} <\mathbf{S}_1^0| &=& <\alpha^\uparrow\overline{\alpha}^\downarrow| \\ <\mathbf{S}_2^0| &=& <\alpha^\uparrow\overline{\alpha}^\downarrow\mathbf{x}\overline{\mathbf{x}}|, \end{array}\right. \qquad \text{Scalar,} \tag{12b}$$

where the suffix L, Rs are omitted for brevity and $\uparrow, \downarrow$ indicate *spin up*, *spin down* states. They play the role of intermediate bosons same as π, ρ in the strong interactions. As Eq.(9) and Eq.(12) contain only α and $\mathbf{x}$ subquarks, we can draw the "*line diagram*" of weak interactions as seen in Fig (1). Eq.(9d) shows that the electron is constructed from antimatters only. We know, phenomenologically, that this universe is mainly made of protons, electrons, neutrinos, antineutrinos and unknown dark matters. It is said that the universe contains almost the same number of protons and electrons. Our model show that one proton has the configuration of (**uud**) : $(2\alpha, \overline{\alpha}, 3\mathbf{x}, \overline{\mathbf{x}})$; electron: $(\overline{\alpha}, 2\overline{\mathbf{x}})$; neutrino: $(\alpha, \overline{\mathbf{x}})$; antineutrino: $(\overline{\alpha}, \mathbf{x})$ and the dark matters are presumably constructed from the same amount of matters and antimatters because of their neutral charges. Note that proton is a mixture of matters and anti-matters and electrons is composed of anti-matters only. This may lead the thought that "the universe is the matter-antimatter-even object." And then there exists a conception-leap between "proton-electron abundance" and "matter abundance" if our composite scenario is admitted (as for the possible way to realize the proton-electron excess universe, see Ref.[14]). This idea is different from the current thought that the universe is made

of matters only. Then the question about CP violation in the early universe does not occur.

Our composite model contains two steps, namely the first is “subquarks made of primons” and the second is “quarks and leptons made of subquarks”. Here let us discuss about the mass generation mechanism of quarks and leptons as composite objects. Our model has only one kind of fermion : Λ and boson : Θ. The first step of “subquarks made of primons” seems to have nothing to do with ’tHooft’s anomaly matching condition[23] because there is no global symmetry with Λ and Θ. Therefore from this line of thought it is impossible to say anything about that α, β, $\mathbf{x}$ and $\mathbf{y}$ are massless or massive. However, if it is the case that the neutral (1,1,1)-states of primon-antiprimon composites (as is stated above) construct the dark matters, the masses of them are presumably less than the order of MeV from the phenomenological aspects of astrophysics. In this connection it is ineresting that Królikowski has showed one possibility of constructing “massless” composite particles(fermion-fermion or fermion-boson pair) controled by relativistic two-body equations[26]. Then we may assume that these subquarks are massless or almost massless compared with $\Lambda_{L,R}$ in practice, that is, utmost a few MeV. In the second step, the arguments of ’tHooft’s anomaly matching condition are meaningful. The confining of subquarks must occur at the energy scale of $\Lambda_{L,R} >> \Lambda_c$ and then it is natural that $\alpha_s, \alpha \to 0$ and that the gauge symmetry group is the spontaneously unbroken $SU(2)_L \otimes SU(2)_R$ gauge group. Seeing Eq.(9), we find quarks and leptons are composed of the mixtures of subquarks and antisubquarks. Therefore it is proper to regard subquarks and antisubquarks as different kinds of particles. From Eq.(8,a,b) we find eight kinds of fermionic subquarks (3 for α, $\overline{\alpha}$ and 1 for β, $\overline{\beta}$). So the global symmetry concerned is $SU(8)_L \otimes SU(8)_R$. Then we arrange :

$$(\beta, \overline{\beta}, \alpha_i, \overline{\alpha}_i \quad i = 1, 2, 3\,)_{L,R} \qquad\qquad in \qquad (SU(8)_L \otimes SU(8)_R)_{global}, \tag{13}$$

where i is color freedom. Next, the fermions in Eq.(13) are confined into the singlet states of the local $SU(2)_L \otimes SU(2)_R$ gauge symmetry and make up quarks and leptons as seen in Eq.(9) (eight fermions). Then we arrange :

$$(\nu_{\mathbf{e}}, \mathbf{e}, \mathbf{u}_i, \mathbf{d}_i \quad i = 1, 2, 3\,)_{L,R} \qquad\qquad in \qquad (SU(8)_L \otimes SU(8)_R)_{global}, \tag{14}$$

where is are color freedoms. From Eq.(13) and Eq.(14) the anomalies of the subquark level and the quark-lepton level are matched and then all composite quarks and leptons (in the 1st generation) are remained massless or almost massless. Note again that

presumably, β and $\overline{\beta}$ in Eq.(13) are composed into "bosonic" $(\beta\beta)$, $(\beta\overline{\beta})$ and $(\overline{\beta\beta})$, which vapour out to the dark matters. Schrempp and Schrempp have discussed about a confining $SU(2)_L \otimes SU(2)_R$ gauge model with three fermionic preons and stated that it is possible that not only the left-handed quarks and leptons are composite but also the right-handed are so on the condition that Λ_R/Λ_L is at least of the order of 3[11]. As seen in Eq.(12a) the existence of composite $\mathbf{W}_R$, $\mathbf{Z}_R$ is predicted. As concerning, the fact that they are not observed yet means that the masses of $\mathbf{W}_R$, $\mathbf{Z}_R$ are larger than those of $\mathbf{W}_L$, $\mathbf{Z}_L$ because of $\Lambda_R > \Lambda_L$. Owing to 'tHooft's anomaly matching condition the small mass nature of the 1st generation comparing to Λ_L is guaranteed but the evidence that the quark masses of the 2nd and the 3rd generations become larger as the generation numbers increase seems to have nothing to do with the anomaly matching mechanism in our model, because, as seen in Eq.(11a,b), these generations are obtained by just adding neutral scalar $\mathbf{y}$-particles. This is different from Abott and Farhi's model in which all fermions of three generations are equally embedded in $SU(12)$ global symmetry group and all members take part in the anomaly matching mechanism[8]. Concerning this, let us discuss a little about subquark dynamics inside quarks. According to "Uncertainty Principle" the radius of the composite particle is, in general, roughly inverse proportional to the kinetic energy of the constituent particles moving inside it. The radii of quarks may be around $1/\Lambda_{L,R}$. So the kinetic energies of subquarks may be more than hundreds GeV and then it is considered that the masses of quarks essentially depend on the kinetic energies of subquarks and such a large binding energy as counterbalances them. As seen in Eq.(11a,b) our model shows that the more the generation number increases the more the number of the constituent particles increases. So assuming that the radii of all quarks do not vary so much (because we have no experimental evidences yet), the interaction length among subquarks inside quarks becomes shorter as generation numbers increase and accordingly the average kinetic energy per one subquark may increase. Therefore integrating out the details of subquark dynamics it could be said that the feature of increasing masses of the 2nd and the 3rd generations is essentially described as a increasing function of the sum of the kinetic energies of constituent subquarks. From Review of Particle Physics[24] we can phenomenologically parameterized the mass spectrum of quarks and leptons as follows :

$$M_{UQ} = 1.2 \times 10^{-4} \times (10^{2.05})^n \quad \text{GeV} \qquad \text{for } \mathbf{u},\mathbf{c},\mathbf{t}, \tag{15a}$$

$$M_{DQ} = 3.0 \times 10^{-4} \times (10^{1.39})^n \quad \text{GeV} \qquad \text{for } \mathbf{d},\mathbf{s},\mathbf{b}, \tag{15b}$$

$$M_{DL} \;=\; 3.6\times 10^{-4}\times (10^{1.23})^n \qquad \mathrm{GeV} \qquad\qquad \text{for } \mathbf{e},\mu,\tau, \tag{15c}$$

where $n = 1, 2, 3$ are the generation numbers and input data are quark masses of 2nd and 3rd generation. They seem to be geometricratio-like. The slope parameters of the up-quark sector and down-quark sector are different, so it is likely that each has different aspects in subquark dynamics. It is interesting that the slope parameters of both down sectors of quark and lepton are almost equal, which suggests that there exist similar properties in substructure dynamics and if it is the case, the slope parameter of up-leptonic(neutrino) sector may be the same as that of up-quark sector, that is, $M_{UL} \sim 10^{2n}$. From Eq.(15) we obtain $M_{\mathbf{u}} = 13.6$ MeV, $M_{\mathbf{d}} = 7.36$ MeV and $M_{\mathbf{e}} = 6.15$ MeV. These are a little unrealistic compared with the experiments[24]. But considering the above discussions about the anomaly matching conditions (Eq.(13,14)), it is natural that the masses of the members of the 1st generation are roughly equal to those of the subquarks, that is, a few MeV. The details of their real mass-values may also depend on the subquark dynamics owing to the effects of electromagnetic and color gauge interactions. These mechanism has studied by Weinberg[29] and Fritzsch[30].

One of the experimental evidences inspiring the SM is the "universality" of the coupling strength among the weak interactions. Of course if the intermediate bosons are gauge fields, they couple to the matter fields universally. But the inverse of this statement is not always true, namely the quantitative equality of the coupling strength of the interactions does not necessarily imply that the intermediate bosons are elementary gauge bosons. In practice the interactions of ρ and ω are regarded as indirect manifestations of QCD. In case of chiral $SU(2)\otimes SU(2)$ the pole dominance works very well and the predictions of current algebra and PCAC seem to be fulfilled within about 5%[19]. Fritzsch and Mandelbaum[9,19] and Gounaris, Kögerler and Schildknecht[10,27] have elaborately discussed about universality of weak interactions appearing as a consequence of current algebra and $\mathbf{W}$-pole dominance of the weak spectral functions from the stand point of the composite model. Extracting the essential points from their arguments we mention our case as follows. In the first generation let the weak charged currents be written in terms of the subquark fields as :

$$\mathbf{J}^+_\mu = \overline{U} h_\mu D, \qquad\qquad \mathbf{J}^-_\mu = \overline{D} h_\mu U, \tag{16}$$

where $U = (\alpha\mathbf{x})$, $D = (\overline{\alpha}\overline{\mathbf{x}}\mathbf{x})$ and $h_\mu = \gamma_\mu(1-\gamma_5)$. Reasonableness of Eq.(16) may given by the fact that $M_W << \Lambda_{L,R}$ (where M_W is $\mathbf{W}$-boson mass). Further, let U and D belong to the doublet of the global weak isospin $SU(2)$ group and $\mathbf{W}^+$, $\mathbf{W}^-$,

$(1/\sqrt{2})(\mathbf{Z}_1^0-\mathbf{Z}_2^0)$ be in the triplet and $(1/\sqrt{2})(\mathbf{Z}_1^0+\mathbf{Z}_2^0)$ be in the singlet of $SU(2)$. These descriptions seem to be natural if we refer the diagrams in Fig.(1). The universality of the weak interactions are inherited from the universal coupling strength of the algebra of the global weak isospin $SU(2)$ group with the assumption of **W**-, **Z**-pole dominance.

4 The mass of Z^0's scalar-partner

Eq.(12a,b) shows that the difference in Z^0 and S^0 essentially originates from the combination of two spins(up-spin and down-spin) of α- and $\overline{\alpha}$- subquark. S^0 has the combination of up- and down-spin and Z^0 has that of up- and up-spin.This situation is similar to hadronic mesons. They are the composite objects of a quark(q) and a anti-quark($\overline{q}$). namely, ρ-π, K^*-K, D^*-D, B^*-B. Each vector meson mass(denoted by $M(V)$) is larger than the mass(denoted by $M(Ps)$) of its pseudo-scalar partner. The mass differences between $M(V)$ and $M(Ps)$ are qualitatively explained by the hyperfine spin-spin interaction in Breit-Fermi Hamiltonian[28]. As the model of the hadronic mass spectra by the Breit-Fermi Hamiltonian is described by use of the semi-relativistical approach, it has some defects in the quantitative estimations, especially in the small mass mesons (such as ρ-π and K^*-K) but qualitatively it is not so bad, namely the explanation of the fact that : $M(V) > M(Ps)$(and else $M(J = 3/2$ baryon$) >$ M(J = 1/2 baryon)). The hyperfine interaction Hamiltonian(denoted by $H^l_{q\overline{q}}$) causing mass split between $M(V)$ and $M(Ps)$ is described as :

$$H^{l=0}_{q\overline{q}} = -\frac{8\pi}{3m_q m_{\overline{q}}}\overrightarrow{S}_q\overrightarrow{S}_{\overline{q}}\delta(|\overrightarrow{r}|), \tag{17}$$

where $\overrightarrow{S}_{q(\overline{q})}$ is a operator of $q(\overline{q})$'s spin with its eigenvalue of 1/2 or -1/2, $m_{q(\overline{q})}$ is quark (anti-quark) mass, l is the orbital angular momentum between q and $\overline{q}$ and $|\overrightarrow{r}| = |\overrightarrow{r}_q - \overrightarrow{r}_{\overline{q}}|$[28].

In QCD theory eight gluons are intermediate gauge bosons belonging to **8** representation which is real adjoint representation. Quarks(anti-quarks) belong to $\mathbf{3}(\overline{\mathbf{3}})$ representation which is complex fundamental representation. Therefore gluons can discriminate between quarks and anti-quarks and couple to them in the "*different sign*".

The strength of their couplings to different color quarks and anti-quarks is described as :

$$\begin{aligned} g\frac{\lambda^a_{ij}}{2} &: \qquad \text{for} \quad \text{quarks} \\ -g\frac{\lambda^a_{ij}}{2} &: \qquad \text{for} \quad \text{anti}-\text{quarks}, \end{aligned} \tag{18}$$

where $a(= 1 \sim 8)$: gluon indices; $i, j(= 1, 2, 3)$: quark indices; λ's : SU(3) matrices and g : the coupling constant of gluons to quarks and anti-quarks(See Fig.(2)). The wave function of a color singlet $q\overline{q}$(meson) system is $\delta_{ij}/\sqrt{3}$, corresponding to $|q\overline{q}>= (1/\sqrt{3})\sum_{i=1}^{3}|q_i\overline{q_i}>$. By use of Eq.(18) the effective coupling for the $q\overline{q}$ system(denoted by α_s) is given by :

$$\begin{aligned} \alpha_s &= \sum_{a,b}\sum_{i,j,k,l}\frac{1}{\sqrt{3}}\delta_{ij}\left(\frac{g}{2}\lambda^a_{ik}\right)\left(-\frac{g}{2}\lambda^b_{lj}\right)\frac{1}{\sqrt{3}}\delta_{kl} = -\frac{g^2}{12}\sum_{a,b}\sum_{j,l}\lambda^a_{jl}\lambda^b_{lj} \\ &= -\frac{g^2}{12}\sum_{a,b}\mathrm{Tr}\left(\lambda^{\mathrm{a}}\lambda^{\mathrm{b}}\right) = -\frac{\mathrm{g}^2}{6}\sum_{\mathrm{ab}}\delta_{\mathrm{ab}} \\ &= -\frac{4}{3}g^2. \end{aligned} \tag{19}$$

Making use of Eq.(17) and Eq.(19) let us write the quasi-static Hamiltonian for a bound state of a quark and a anti-quark is given as :

$$H = H_0 + \alpha_s H^{l=0}_{q\overline{q}}. \tag{20}$$

Calculating the eigenvalue of H in Eq.(20) we have :

$$M(V\mathrm{or}S) = M_0 + \xi_q < \overrightarrow{S}_q\overrightarrow{S}_{\overline{q}} >, \tag{21}$$

where ξ_q is a positive constant which incldes the calculation of α_s. In Eq.(21) it is found that $< \overrightarrow{S}_q\overrightarrow{S}_{\overline{q}} >= -3/4$ for pseudoscalar mesons and $< \overrightarrow{S}_q\overrightarrow{S}_{\overline{q}} >= 1/4$ for vector mesons and then we have :

$$\begin{aligned} M(Ps) &= M_0 - \frac{3}{4}\xi_q \\ M(\,V\,) &= M_0 + \frac{1}{4}\xi_q. \end{aligned} \tag{22}$$

Eq.(22) results that :

$$M(V) > M(Ps). \tag{23}$$

Here let us turn discussons to "intermediate weak bosons". As seen in Eq.(12a,b) Z^0 weak boson has its scalar partner S^0 and both of them contain "*fermionic*" α_L and $\overline{\alpha}_L$ as subquark elements. Referring Eq.(8a) we find that both of α_L and $\overline{\alpha}_L$ belong to "adjoint **3**" state of $SU(2)_L$(which is the real representation) and then $SU(2)_L$-hypercolor gluons cannot distingush α_L from $\overline{\alpha}_L$. Therefore the hypercolor gluons couple to α_L and $\overline{\alpha}_L$ in the "*same sign*". This point is distinguishably dfferent from hadronic mesons (Refer Eq.(18)). The wave function of a hypercolor singlet $(\alpha\overline{\alpha})$-system is $\delta_{ij}/\sqrt{3}$, corresponding to $|\alpha_i\overline{\alpha}_i >= (1/\sqrt{3})|\sum_{i=1}^{3}|\alpha_i\overline{\alpha}_i >$ where $i = 1, 2, 3$ are different three states of the triplet of $SU(2)_L$.

The strength of their couplings to diferrent hypercolor subquarks and anti-subquarks is described as :

$$
\begin{aligned}
&g_h\frac{\tau^a_{ij}}{2} \quad : \qquad\qquad \text{for} \quad \text{subquark} \\
&g_h\frac{\tau^a_{ij}}{2} \quad : \qquad\qquad \text{for} \ \ \text{anti}-\text{subquark},
\end{aligned} \tag{24}
$$

where $a(= 1, 2, 3)$: hypercolor gluon indices; $i, j(= 1, 2, 3)$: subquark and anti-subquark indices and τ : $SU(2)$ matrices and g_h : the coupling constant of hypergluons to the subquarks and anti-subquarks(See Fig.(2)). By use of Eq.(24) the effective coupling (denoted by α_W) is given by :

$$
\begin{aligned}
\alpha_W &= \sum_{a,b}\sum_{i,j,k,l}\frac{1}{\sqrt{3}}\delta_{ij}\left(\frac{g_h}{2}\tau^a_{ik}\right)\left(\frac{g_h}{2}\tau^b_{lj}\right)\frac{1}{\sqrt{3}}\delta_{kl} = \frac{g_h^2}{12}\sum_{a,b}\sum_{j,l}\tau^a_{jl}\tau^b_{lj} \\
&= \frac{g_h^2}{12}\sum_{a,b}\mathrm{Tr}\left(\tau^{\mathrm{a}}\tau^{\mathrm{b}}\right) = \frac{\mathrm{g_h^2}}{6}\sum_{\mathrm{ab}}\delta_{\mathrm{ab}} \\
&= \frac{1}{2}g_h^2,
\end{aligned} \tag{25}
$$

where $a, b = 1, 2, 3$; $i, j, k, l = 1, 2, 3$. Note that α_s (in Eq.(19)) is "*negative*" and α_W(in Eq.(25)) "*positive*". Through the same procedure as hadronic mesons the masses of Z^0 and S^0 are described as :

$$
M(Z^0\,\mathrm{or}\,\mathrm{S}^0) = \mathrm{M}_0 - \xi_{\mathrm{sq}} < \overrightarrow{S}_\alpha\overrightarrow{S}_{\overline{\alpha}} >, \tag{26}
$$

where ξ_{sq} is a positive constant which includes the calculation of α_W and $\overrightarrow{S}_{\alpha(\overline{\alpha})}$ is the spin operator of $\alpha(\overline{\alpha})$. In Eq.(26) it is calculated that $< \overrightarrow{S}_\alpha\overrightarrow{S}_{\overline{\alpha}} >= -3/4$ for scalar :

S^0 and $< \overrightarrow{S}_\alpha \overrightarrow{S}_{\overline{\alpha}} >= 1/4$ for vector : Z^0 and then we get :

$$\begin{aligned} M(S^0) &= M_0 + \frac{3}{4}\xi_{sq} \\ M(Z^0) &= M_0 - \frac{1}{4}\xi_{sq}. \end{aligned} \tag{27}$$

From this it follows that :

$$M(S^0) > M(Z^0). \tag{28}$$

Here let us define :

$$\begin{aligned} \tilde{M} &= \frac{1}{2}\left(M(S^0) + M(Z^0)\right), \\ \Delta &= M(S^0) - M(Z^0), \\ R &= \frac{\Delta}{\tilde{M}}. \end{aligned} \tag{29}$$

Experimentally it is reported : $M(Z^0) = 91\text{GeV}$[24], with which using Eq.(29) we obtain :

$$\begin{aligned} R &= 0.1 \qquad M(S^0) \approx 100 \text{ GeV}, \\ R &= 0.2 \qquad M(S^0) \approx 110 \text{ GeV}. \end{aligned} \tag{30}$$

Therefore if the existence of the scalar particle whose mass is a little above Z^0's mass is confirmed in future it may be a scalar partner of Z^0 and that might suggest the possibility of the subquark structure.

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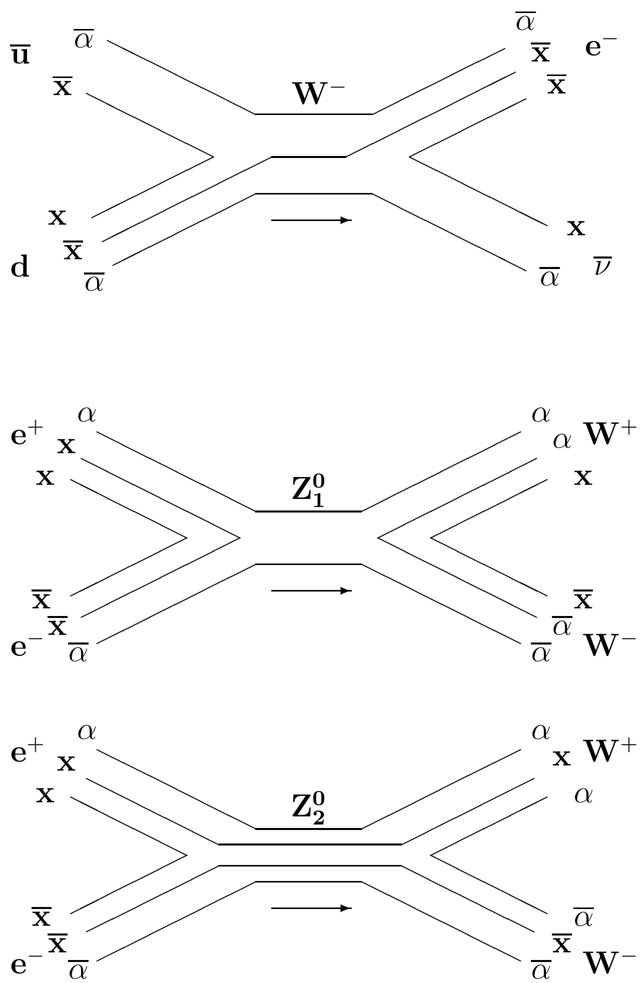

Figure 1: Subquark-line diagrams of the weak interactions

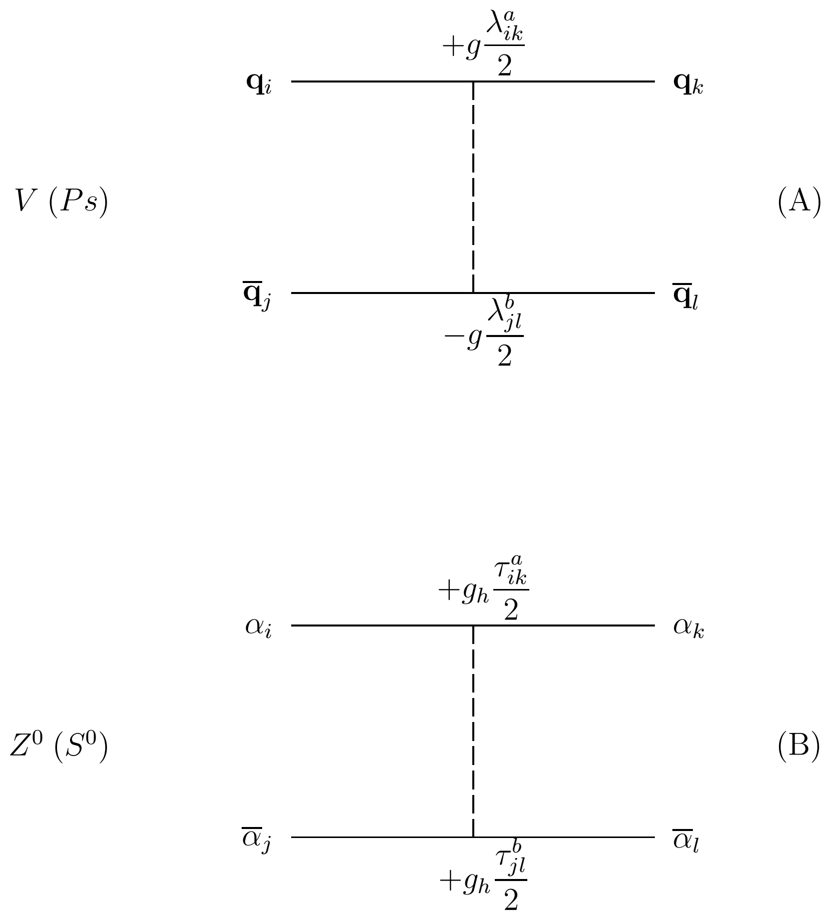

Figure 2: (A) Gluon exchange in $\mathbf{q}\overline{\mathbf{q}}$ system; (B) Hypergluon exchange in $\alpha\overline{\alpha}$ system.